A systematic review on the use of cancer-specific
Patient centered technologies among underserved populations

Review

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Introduction

In the US, more than 1.6 million new cases of cancer are estimated to be diagnosed each year [1], however, the burden of cancer among the US population is not shared equally. Medically underserved populations (i.e. groups with economic barriers, or cultural and/or linguistic barriers to primary medical care services [2]) such as racial and ethnic minorities and individuals of lower socioeconomic status [3], have a higher cancer burden when compared to their counterparts which can be partially attributed to differences in the access to, and quality of, care they receive [4-6]. A wide range of technologies are available to patients, including personal health records [PHRs] [7], Internet-based [eHealth] technologies [8, 9], mobile [mHealth] applications [10], and telemedicine [11]. These technologies have the potential to improve access to care by patients and empower individuals to participate more actively in their care [12, 13]. For example, there is evidence that patient-centered technologies (also commonly referred to as consumer health information technologies) provide patient-centered care by increasing patients’ quality of health care [14], improving communication with providers [11, 15-17], providing tailored education and lifestyle messages [18] [14], and promoting self-management of health care [19]. While these health information technologies have also been proposed as a means to reduce health care disparities [13, 20-22], little is known about their use among underserved populations.

To date, reviews on the use of patient-centered technologies have largely focused upon the general population. For example, a recent review by Kim and Nahm [23] found several benefits to the use of patient-accessible personal health records, including consumer empowerment, improved patient-provider communication, increased access to data during times
of emergency, improved chronic disease management, and increased likelihood of behavior change. Several concerns were also raised regarding the broader dissemination of personal health records, including data privacy and security; data accuracy, health literacy, and the digital divide. With regards to mobile technologies, Krishna and colleagues [24] found significant improvements in medication adherence, smoking quit rates, self-efficacy, and other health outcomes (e.g., asthma symptoms, blood sugar control, stress levels). Limited attention has also been given to the potential of patient-accessible personal health records (PHRs) among specific disease classes [25, 26], however, Price and colleagues [27] found PHR interventions targeting asthma, diabetes, fertility, glaucoma, HIV, hyperlipidemia, and hypertension (but not cancer) to have beneficial effects such as better quality of care, improved access to care, and increased productivity. Racial/ethnic minority populations have been targeted to interventions to facilitate weight loss; overall, Internet-based technologies (eHealth) were only able to effect short term weight loss, while mobile technologies (mHealth) provided no benefit [28]. Montague and colleagues [29] also found that technologies can positively affect the health of the underserved if they are effectively tailored, but little is known of how to effectively tailor cancer-specific technologies to this population.

The purpose of this article is to systematically review current evidence on the use of cancer-specific patient-centered technologies among underserved populations. The current review contributes to both the informatics and cancer health disparities literature by seeking to address the following issues: 1) to understand the effect or impact of patient-centered technologies on the health or health care outcomes of underserved populations, 2) to understand the use, usability, and acceptance of patient-centered technologies and efforts to tailor their design to improve cancer care among underserved populations, 3) to understand the barriers and
facilitators to patient-centered technology use for different populations, and 4) to propose directions for future research based on the current literature.

**Conceptual Framework**

Patient-centered technologies by underserved populations is influenced by multiple factors. For purposes of this review, we have adapted an existing health services research framework to organize the factors that influence the use and acceptance of information technology among individuals. Originally developed with the organization in mind, the unified theory of acceptance and use of technology (UTAUT) [30] sought to understand the critical factors related to the prediction of behavioral intention to use technologies within the organizational context.

According to the UTAUT, there are three constructs (i.e., performance expectancy, effort expectancy, and social influence) which are considered direct determinants of the intention to use technology (see Table 1 and Figure 1). *Performance expectancy* refers to the degree to which using a technology will provide benefits to consumers in performing certain activities. In the health context, benefit examples may include managing chronic conditions or receiving health information to facilitate behavior change. *Effort expectancy* refers to the degree of ease associated with the consumers’ use of technology (i.e., usability). *Social influence* refers to the extent to which consumers perceive important others, such as their family and friends, to believe they should use a particular technology. Separately, there are two constructs within this framework (i.e., intention and facilitating conditions) which are considered direct determinants of technology usage behavior, with facilitating conditions referring to the perception of resources and support available to perform a behavior. In addition, there were four moderators embedded
in this original framework which contributed to understanding the acceptance of technology by individuals (i.e., age, gender, experience, and voluntariness of use).

In order to tailor this theory to the consumer use of technology, Venkatesh and colleagues developed UTAUT2 [31]. Given the focus of the current study, it seems especially apt to use this tailored theory to understand minorities’ use of patient-centered technologies. Under this remodeled framework, three key constructs on the general and consumer adoption and use of technologies have been identified and incorporated into UTAUT. These additional constructs are: 1) hedonic motivation [the fun or pleasure derived from using a technology], 2) price value [the monetary cost of use on the individual], and 3) experience [the passage of time from initial use of the technology] and habit [the extent to which an individual believes the behavior to be automatic].

<table>
<thead>
<tr>
<th>Table 1. Constructs of the consumer acceptance model of the unified theory of acceptance and use of technology (UTAUT2)</th>
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<tbody>
<tr>
<td><strong>UTAUT Constructs</strong></td>
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<tr>
<td>Performance expectancy</td>
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<td>Effort expectancy</td>
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<td>Social influence</td>
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<td><strong>UTAUT2 Constructs</strong></td>
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<td>Hedonic motivation</td>
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<td>Price value</td>
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<td>Experience</td>
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<td>Habit</td>
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Methods

Search Strategy

Recommendations of the statements on enhancing transparency in reporting the synthesis of qualitative research (ENTREQ) [32] and the preferred reporting items for systematic reviews and meta-analyses (PRISMA) [33] were followed whenever appropriate. Computer-based searches were conducted in the following academic databases: 1) PubMed [cancer subset]; 2) MEDLINE, 3) PsycINFO; and 4) CINAHL. In order to optimize search results, we used various combinations of key words taken from the existing literature and Medical Subject Headings (MeSH) terms. For example, to capture articles examining the use of mHealth technologies, we
used keywords and phrases such as “m-health”, “mhealth”, “mobile technologies”, “mobile health”, etc. A complete list of search terms can be found in Table 2. Lastly, we identified additional studies using a snowball searching technique whereby the reference lists of studies that met our inclusion criteria were examined.

Table 2. Operationalization of the search terms

<table>
<thead>
<tr>
<th>Category</th>
<th>Search Terms</th>
</tr>
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<tbody>
<tr>
<td>Cancer</td>
<td>cancer, neoplasms</td>
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</table>

Notes: Search terms within each category are combined with OR. Search terms between categories are combined with AND. Some terms were truncated. Asterisk (*) denotes truncation of search term to capture keywords with the same stem.

Inclusion Criteria

For the current review, we sought to identify articles that appeared in peer-reviewed journals and were published in the English language. We included both qualitative studies and quantitative studies and excluded non-empirical studies such as commentaries, as well as international studies. Similar to other reviews [29], we limited eligible studies to those conducted in the United States because sociocultural differences in the US may be unique from other countries. Studies were included if they assessed the effect of patient-centered technologies, or explored factors associated with the use of these technologies, among underserved populations. More specifically, topics of interest for this review included: 1) the effect or impact of these technologies on the health or health care outcome studied, 2) the use,
usability, and acceptance of these technologies and efforts to tailor their design to populations of interest, 3) facilitators and barriers to the use of patient-centered technologies among underserved populations, , and 4) lessons learned from studies assessing the effect of these technologies involving underserved populations. Studies were included if they focused exclusively on underserved populations, or underserved groups represented at least 40% of their sample size. To categorize the HIT applications of interest in this research, the following definitions were used:

**Definitions**

**eHealth.** While no standard definition for eHealth exists [9], the term eHealth has been used broadly in the literature to refer to technologies ranging from CD-ROMs to the Internet. For purposes of this project, eHealth is defined as “…the use of emerging information and communication technology, especially the Internet, to improve or enable health and healthcare” [34].

**mHealth.** mHealth technologies are defined as “…a personalized and interactive service whose main goal is to provide ubiquitous and universal access to medical advice and information to any users at any time over a mobile platform” [35]. mHealth technologies can include the use of cellphones, smartphones, and tablets by patients and/or health care providers.

**Telemedicine.** Telemedicine has been defined as “…a branch of e-health that uses communications networks for delivery of healthcare services and medical education from one geographical location to another” [36]. The concept of distance is essential, for example, telemedicine can improve access to care to rural populations by eliminating distance as a barrier.
Study Selection

We conducted a systematic search for studies that reported either quantitative or qualitative empirical findings of the use of patient-centered technologies among underserved populations that were published up until October of 2016. Each study was individually assessed for relevance. Any disagreements between reviewers were reconciled by consensus. We used a 3-step inclusion process which is illustrated in Figure 2. In step 1, we examined article titles and excluded articles that clearly did not have a focus on either patient-centered technologies or cancer care. When either of these focus areas was unclear when reviewing the titles, we erred on the side of inclusion and included these citations for abstract review. In step 2, the abstracts of citations were retrieved and examined for all studies that were not excluded during the phase 1 review. Similarly, we then excluded article abstracts that clearly did not have a focus on either patient centered technologies or cancer care. Lastly, the full-text articles of the remaining citations were obtained for independent assessment of all inclusion criteria.

Figure 2. Systematic review flowchart
Data Extraction

Information systematically extracted from the articles included the following: study design; including the targeted cancer and/or stage of the cancer care continuum [37]. The continuum of cancer care refers to the delivery of cancer health care over a period of time, covering phases of the illness which includes prevention, detection, diagnosis, treatment, survivorship, and end-of-life care [38]. In addition, we extracted information on the underserved population of interest; whether the patient-centered technology focused on healthy individuals, cancer patients or survivors, caregivers, or health care providers; sample size; the type of patient-centered technology used; the study outcome of interest; and whether there was any evidence of tailoring when it came to the technology intervention. Tailoring is defined as “Any combination of information or change strategies intended to reach one specific person, based on characteristics that are unique to that person, related to the outcome of interest, and have been derived from an individual assessment” [39]. Also, when available we describe the technology’s use (whether patients adopt the tool), usability (the patient’s experience using the tool), and usefulness (the extent to which it meets the patient’s needs). Lastly, we describe barriers and facilitators to the use of the technologies reported in the article.

Results

Studies Included

Our keyword search identified an initial yield of 2,802 citations (see Figure 2). After removing duplicates, our initial search yield was reduced to 1,276 studies. After applying the restrictions for inclusion in the title and abstract review, 1,205 studies were excluded. The primary reasons for exclusion are identified in Figure 2 leaving 71 included studies (marked with an asterisk in the reference list) published between 1995 and 2016.
Study Characteristics

The characteristics of the studies are summarized in Table 3. Studies varied with regards to the underserved population targeted, the technology used, and the cancer type of interest. A large proportion of studies included in our review target blacks or African-Americans (n=31; 43.7%) followed by rural populations (n=14; 19.7%). More than half of the included studies assessed eHealth technologies (n=41; 57.7%). Also, the largest proportion of studies focused on breast cancer (n=26; 36.6%). In addition, the largest proportion of technological outcomes assessed was use of technology (n=20; 28.2%) while knowledge (n=15; 21.1%) was the largest proportion of health outcomes assessed. Observational studies represented the largest proportion of studies included in our review (n=32; 45.1%). Fifteen studies followed an experimental design (21.1%) while the remaining 24 studies were either qualitative (n=13; 18.3%) or mixed methods (n=11; 15.5%).

To provide a consistent structure, the remainder of the results section is organized as follows. Study summaries are stratified by the type of patient-centered technology. Within each patient-centered technology section, we then further stratify by study design: experimental (Appendix 1), observational (Appendix 2), and qualitative studies (Appendix 3).

Table 3. Characteristics of studies included in this review (n=71)

<table>
<thead>
<tr>
<th>Underserved Population</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Indian/Alaska Native</td>
<td>3 (4.2)</td>
</tr>
<tr>
<td>Asian</td>
<td>6 (8.5)</td>
</tr>
<tr>
<td>Black/AA</td>
<td>31 (43.7)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>12 (16.9)</td>
</tr>
<tr>
<td>Diverse pop</td>
<td>4 (5.6)</td>
</tr>
<tr>
<td>Low-Income</td>
<td>6 (8.5)</td>
</tr>
<tr>
<td>Rural</td>
<td>14 (19.7)</td>
</tr>
<tr>
<td>Patient-centered technology</td>
<td></td>
</tr>
<tr>
<td>Computer/Internet-based technology</td>
<td>41 (57.7)</td>
</tr>
<tr>
<td>Mobile application (mHealth)</td>
<td>15 (21.1)</td>
</tr>
<tr>
<td>eHealth and mHealth</td>
<td>5 (7.0)</td>
</tr>
</tbody>
</table>
Theme 1. The effect of use on clinical and other outcomes

eHealth. Ten eHealth studies were identified using an experimental design, with 9 of these using a randomized controlled trial [40-49] (Appendix 1). These studies primarily targeted African-Americans (n=7), as well as colorectal (n=6) and breast (n=4) cancer. Findings showed predominantly positive impacts of eHealth interventions, ranging from computer-assisted
programs and web-based decision aids to tailored, interactive soap operas. Primary outcomes assessed included knowledge (n=5) and screening uptake (n=3).

For example, Champion and colleagues [40] used a randomized control trial to compare the efficacy of three interventions in promoting routine mammography screening among low-income African-American women. This study found that an interactive computer-assisted instruction program produced the greatest adherence to mammography (40.0%) when compared to participants receiving an education pamphlet (32.1%) or a culturally appropriate video (24.6%). Jibaja and colleagues [45] used an interactive soap-opera format to promote the early detection of breast cancer among high-risk Hispanic women. The use of this culturally tailored, computer-based educational program was found to significantly increase breast cancer screening knowledge and beliefs when compared to a comparison group.

**mHealth.** Three mHealth studies were identified using an experimental design [50-52]. Using a quasi-experimental design, Lee and colleagues [52] tested a tailored interactive 7-day text message intervention designed to increase knowledge and vaccination of HPV. This study found a significant increase in knowledge and intent to get vaccinated. In addition, HPV vaccination uptake increased by 30% among participants in the intervention. Targeting a Hispanic population for CRC screening, Fernandez and colleagues [51] used a randomized controlled trial to compare (1) a tailored interactive multimedia intervention, (2) a lay health worker delivered media print intervention, and (3) a no intervention control group. No statistically significant differences were found among the study arms. Among a population that included a significant proportion of African-Americans (40.5%), Yanez and colleagues [50] found that a web-based psychosocial intervention delivered via a tablet achieved good retention (>85%) and attendance rates (>70%), and received favorable evaluations (mean score, 4/5) and
exit surveys (mean score: 3.6/4). The intervention also reduced depressive symptoms and improved relaxation self-efficacy.

Two additional studies using a mixed methods approach with an experimental component were also identified. Among a sample of Korean American women, a 7-day mobile phone text message-based cervical cancer screening intervention significantly increased participants’ knowledge of cervical cancer and screening recommendations, as well as the uptake of cervical cancer screening [53]. In a sample of Spanish-speaking Latina women seeking care at a federally qualified health center, test messaging reduced the number of days between an abnormal mammogram and participants’ return for follow-up when compared to women who did not receive text message notifications [54].

**Telemedicine.** Two telemedicine studies were identified using an experimental design (Appendix 4) [55, 56]. Kroenke and colleagues [56], using a RCT design, found that telecare management improved depression and pain outcomes in both urban and rural cancer patients. In another RCT, telegenetics was compared with in-person cancer genetic counseling in terms of its impact upon attendance, patient satisfaction, and cost [55]. This study found that while costs were significantly less, telegenetics did not differ in patient satisfaction from in person genetic counseling, but patients seeking in-person genetic counseling were more likely to attend counseling sessions.

**Theme 2. Behavioral intention to use, use, and usefulness of patient-centered technology**

**eHealth.** Seventeen observational studies were identified for eHealth, primarily targeting African-Americans (n=9) (Appendix 2) [57-73]. Most studies assessed cancer in general (n=8), with breast cancer being the most frequent single site focus (n=6). Studies found that the internet
was the first source of cancer information, followed by health care providers, for Hispanics [57] and blacks [64]. In addition, email and web-based information was preferred over mail [67]. Song and colleagues [71] found the Internet to be the least relied upon source of information, compared to…, among a low-income population. A majority of studies assessed technology use as an outcome (n=15).

In an early study, Gustafson and colleagues [62] examined the feasibility of an interactive, computer-based system in reaching low-income, underserved women with breast cancer (n=229; n=85 African Americans) [74]. Low-income women were more likely to use and spend more time on the computer-based system when compared to another population of more affluent women. In addition, low-income urban African-Americans were more likely to use the system to access information and for health management services, while low-income whites were more likely to use communication services. The Young Sisters Initiative: A Guide to a Better You! program is a website designed for young breast cancer survivors. Using a mixed methods approach which included a post-use survey of 1,442 site visitors (93% African-American women); participants reportedly found value in using the website for reproductive and psychosocial information and support [75]. Chee and colleagues [76] conducted a usability test and RCT pilot intervention to determine the efficacy of a culturally tailored registered nurse-moderated Internet Cancer Support Group. This study found positive effects on supportive care needs, psychological and physical symptoms, and quality of life.

In addition to personal computer use, the use of computer kiosks was explored among underserved populations. Kreuter and colleagues [58] sought to understand the ideal placement (e.g., beauty salons, churches, neighborhood health centers, laundromats, social service agencies, health fairs, and public libraries) to reach African-American women for the purpose of providing tailored breast cancer information. This study found that only laundromats resulted in both
frequent kiosk use and reaching high need populations (i.e., a large proportion of users with no health insurance, unaware of where to get a mammogram, reporting no recent mammogram and barriers to getting one, and having little knowledge about breast cancer and mammography).

**mHealth.** Seven observational studies were found assessing mHealth (n=2) [77, 78], or both mHealth and eHealth studies (n=5) [79-83]. Surveying 156 Hispanic and non-Hispanic rural women, Kratzke and Wilson [77, 80] found that nearly 87% of study participants used cell phones while 47% used text messaging as a means to communicate. When compared to non-Hispanic women, Hispanic women (n=36) were more receptive to breast cancer prevention voice messages and text messages. In another survey of Hispanic women (n=905), Dang and colleagues [79] found that more than half of participants did not use the Internet (58%) or email (64%), but a large proportion of participants used mobile phones (70%). In addition, 65% of all participants used text messages with 45% wishing to receive mammogram reminders via text. Schoenberger and colleagues used focus groups to assess the usage and acceptance of mobile communication technologies to provide cancer information among community health advisors (n=37) [84] and health ministry leaders (n=37) [85]. Among CHAs, a majority of participants reported owning a mobile phone (89%) or a smartphone (67%), and 33% use text messaging as a means to communicate. All HMLs reporting owning a cell phone, while 85% reported using text messaging as a means to communicate.

**Telemedicine.** Eight telemedicine studies were identified using an observational design (Appendix 4) [86-93]. Three studies focused on genetic counseling. Using surveys, McDonald and colleagues [91] sought to understand the acceptability of telegenetics among Maine residents living in remote areas. The most important characteristics of telegenetics models of care were
perceived to be professional qualifications (92.2%) and one-on-one counseling (65.1%), whereas in-person and local counseling was ranked lower (51.8% & 52.1%, respectively).

Telemedicine was commonly used to provide psychosocial support. Rural lung, breast, and colorectal cancer patients reported a high level of satisfaction with a videophone-based intervention providing dignity psychotherapy [92]. Among a sample of Alaskan native breast cancer patients, an interactive audio and video telemedicine program providing medical consultation received overall high patient satisfaction [93]. In a sample of rural American Indian and Alaska Natives in Washington, cancer survivors were surveyed about their experiences with a telehealth cancer support group [87]. Members reported value in interacting with other cancer survivors and usefulness of the information presented. Specific topics of interest included nutrition during treatment, as well as side effects of treatment.

**Theme 3. Perceptions and satisfaction of use of patient-centered technologies**

**mHealth.** Five qualitative studies related to mHealth were identified (Appendix 3) [85, 94-97]. Qualitative studies primarily targeted black/AA (n=2) or Hispanic (n=2) populations and breast cancer (n=3) patients. These studies assessed outcomes related to content design and implementation (n=3) and usability/acceptability (n=2). Weaver and colleagues [98] used focus groups to assess the perceptions of colorectal cancer text messages among a majority African-American population (n=16; 62%). Although initially expressing reluctance to use personal technologies as a means to receive CRC information, participants responded favorably when shown sample text messages. Features that participants were interested in seeing with respect to text messages were personalized messages, content that was relevant to them, and messages that were positive and reassuring. Conversely, participants did not want to receive test results or bad
news via text messages, or content that included shorthand phrases or required complex replies. In a group of healthy African-American men who received a prostate cancer educational intervention consisting of short text messages related to prostate cancer awareness, Le and colleagues [99] found that 65% of the participants wished to continue receiving text messages pertaining to workshop reminders, post-workshop reinforcement, spiritual/motivational messages, and retention after completing the study. However, more than one-third of the study participants did not recall receiving the text messages.

Bravo and colleagues [94] used semi-structured interviews to assess the attitudes, acceptance, and usability of a breast cancer risk assessment tool accessed via tablet among underserved women seeking care at a safety net institution. A majority of women preferred the mobile app over a paper version of the assessment tool. All participants found the application easy to use.

**eHealth.** Seven qualitative studies [100-106] and 7 mixed methods [75, 76, 107-111] related to eHealth were identified. Qualitative studies primarily targeted black/AAs (n=3) or diverse populations (n=2) and target breast (n=3) and prostate cancer (n=3) patients. These studies largely assessed outcomes related to usability/acceptability (n=3) and content design (n=2). For example, Berry and colleagues [100] evaluated the usability of a web-based decision aid designed to improve decision-making among English-speaking Latino men (n=7) with localized prostate cancer. This eHealth intervention was tailored to participants’ personal factors (e.g., personal characteristics, confidence in doctor, influential people, etc.) and used expert recommendations to communicate health benefits and risks. Overall, participants rated the intervention with high acceptability ratings. However, Berry et al. found several usability issues related to *content comprehension* where Hispanic participants did not initially understand
concepts until provided a short definition; navigation issues when answering multiple choice questions, using check boxes, typing responses with a keyboard, or clicking links to access external pages; and sociocultural appropriateness where some subgroups of the population (e.g., Latino men in poverty) did not have computers at home and would therefore not use the application.

Theme 4. Barriers and facilitators to use of patient-centered technologies

**Barriers.** Text messaging was found to be beneficial as it provided a form of communication allowing for the quick dissemination of health information. The main barrier to text messaging was the lack of knowledge of how to text among some participants. Increasing knowledge through education was found to be the most feasible solution. Another barrier to successful outcomes from text messaging [99] was recall, wherein some participants did not remember receiving text messages. This problem could have arisen from technical issues and suggested the importance of incorporating a component into the intervention which verified that messages had been received.

**Facilitators.** Participants considered the mobile application to be easy and fun to use with easy to read text. In addition, participants were motivated to use the tool as it was new and innovative. While participants reported being unfamiliar with the technology (iPad) and experienced challenges with health literacy and recall, as well as security concerns, they had an interest in keeping up with technology. Some suggestions identified when designing mHealth applications for this population include writing the content at the appropriate literacy levels, making instruction and assistance in using the mHealth application available, and minimizing the
amount of new skillsets that participants will need to learn in order to use the mHealth application.

**Discussion**

The purpose of this study was to review the current evidence on the use of cancer-specific patient-centered technologies among the underserved. While the reviewed studies targeted various underserved populations including racial and ethnic minorities (e.g., blacks/African-Americans and Hispanics), low-income, and rural populations; we identified two cross-cutting issues that the literature suggests should be taken into account when implementing patient-centered technology interventions: 1) training in the use of patient-centered technologies, and 2) tailoring patient-centered technologies to target populations.

The landscape of technology in our digital age is rapidly changing. This growth has led to several advances in health promotion from accessing health information digitally to using technology to track health and fitness [112]. In addition, the Internet and mobile devices have become a prominent vehicle to reach diverse minority populations and deliver health information [113-118]. Use of the Internet within the home is lower in individuals who are older, belong to a racial/ethnic minority group, are less educated, and have lower incomes [119, 120]; however, the Internet has become more accessible in many ways due to the proliferation of mobile devices. For example, blacks are more likely to access the Internet with their mobile phone than their non-Hispanic white counterparts [119].

Much of the evidence related to mobile devices was devoted to the use of text messaging as a means to provide health information and facilitating behavior change. These results are promising given the consistent findings that underserved populations are receptive to the use of these technologies for cancer prevention and care uses. Contributing factors to this growth, and
the intention to use these technologies, may be traced back to the constructs of social influence, price value, and habit. According to the Pew Research Center, text messaging is being used by more than 90% of the population within each age group (100% of 18-29, 98% of 30-49, 92% of 50+) [121]. Due to this widespread use and already established habit of communicating with others, individuals are likely to adopt this form of technology in order to communicate with their social group. Due to the way in which this method of communication is ingrained into the day-to-day lives of individuals, the time cost of adopting these technologies is minimal due to their pervasiveness. In addition, using smartphones may be considered a low-cost alternative to accessing the Internet when compared to home Internet.

Mobile devices provide a means to reach minority populations and offer the potential to reduce access issues with respect to health care and health information. However, barriers still exist which prevent the effective use of these technologies. In addition to creating opportunities to advance health promotion, the rapid growth in technology also presents several challenges. One of the most prominent challenges facing users is the pressure to remain current with new technologies, their increasing effort expectancy, or the degree of ease associated with technology use. Clearly, realizing the full potential benefit of these technologies is dependent on their effective use. While studies found that underserved populations are receptive to the use of patient-centered technologies, a recurrent challenge found in the literature was a lack of knowledge as to how to use new applications of the technology, as well as the technology itself. These challenges should not be overlooked and range from receiving health information via text messages to using interactive iPads.

**Education and training to facilitate the use of patient-centered technologies**
Some of these difficulties with use could be remedied by facilitating conditions, for example, providing a short training session at the same time the technology is introduced. Public libraries have been successful in improving decision making in accessing high-quality health information, reducing computer anxiety, and increasing computer interest and self-efficacy among older adults [122, 123], and health care providers could leverage or learn from these community institutions. However, other technologies may require substantial modifications to the intervention in order to remove obstacles and barriers individuals may experience in order to facilitate their use. Interventions should incorporate usability and feasibility testing with target populations into their development process in order to identify unanticipated issues, as well as appropriate training of target populations in the use of the technologies. While such methods need to be applied efficiently in order to minimize their time and resource burden, up-front investment in such approaches can be the difference between a successful or failed implementation. In some cases, new technologies may not be a good fit with underserved populations, for example, low-income individuals may have insurmountable barriers to obtaining expensive new devices. Patients with disabilities, whether mental or physical, may not have the capacity to adapt to new technologies that require significant cognitive load or fine motor skills. In these cases, alternative communication channels may be necessary to deliver a desired behavioral or clinical intervention; we want to be careful to construct patient-centered technologies versus technology-centered patients.

**Tailoring to facilitate the use of patient-centered technologies**

When using interactive technologies (i.e., computer-based media that enable users to access information and services of interest, control how the information is presented, and
respond to information and messages in the mediated environment [124]) an important feature is 
the ability to tailor information to the recipients’ needs and interests [124, 125]. It is necessary to 
consider the unique cultural norms and/or challenges of underserved populations when tailoring 
communication strategies. Robust methods to account for these differences in the design and 
implementation of technology interventions targeting specific groups is a key area in need of 
development. Hispanics may be better reached with technologies framed with health education 
content tailored to this population to improve both content comprehension and acceptance. For 
example, the use of telenovelas and soap operas is a novel approach that appeals to underserved 
Spanish-speaking women’s cultural norms and has been found to increase breast cancer 
screening knowledge and beliefs [45]. Similarly, a culturally tailored educational video 
including a soap opera and physician recommendation segment made in Chinese was found to 
increase Chinese women’s intention to get screened for breast cancer, in addition to increasing 
their knowledge, perceived risk and perceived benefits of screening [110].

Cultural competence is another strategy to reduce health and health care disparities that 
may be applied to the tailoring of patient-centered technologies. Cultural competence is defined 
as “…understanding the importance of social and cultural influences on patients’ health beliefs 
and behaviors; considering how these factors interact at multiple levels of the health care 
delivery system (e.g., at the level of structural processes of care or clinical decision-making); 
and, finally, devising interventions that take these issues into account to assure quality health 
care delivery to diverse patient populations” [126]. Tailoring patient-centered technologies to 
patients may help overcome sociocultural barriers to providing health care, one being a lack of 
culturally/linguistically appropriate health education materials [126]. By understanding unique 
differences among underserved groups, we can better understand how to reach each population,
how they spend their time and use technology, and how different forms of technology may be
used in different home and community settings. In addition, this approach allows researchers to
tailor the technology based on who an individual is and how their identity is constructed before
the technology is implemented.

**Directions for Future Research**

**Digital divide.** The use of patient-centered technologies may be seen as a means to reach
underserved populations; however, there are several concerns within the health care research
community related to their use. Of particular interest is the decreased access of technologies
among racial and ethnic minorities, persons with disabilities, rural populations, older populations
(including veterans), and individuals with lower socioeconomic status; a phenomenon commonly
referred to as the digital divide [127, 128]. More research needs to assess the health information
needs of these underserved populations and how they prefer to receive health information. When
the use of technology may not be appropriate for providing patient-centered care, the use of other
tailored interventions may be more successful.

**Under-represented cancers and underserved populations.** While several studies have
targeted breast cancer, colorectal, and prostate cancer; only a few studies have targeted other
cancers. Future research on the use of patient-centered technologies among underserved
populations should focus on under-represented cancers such as lung, ovarian, and cervical
cancer. Furthermore, less prevalent cancers have not seen the same level of technology
development targeting their unique clinical needs. In addition, there are underserved populations
which have received little attention in the current literature. Studies predominantly targeted
black or African-Americans and Hispanic populations. Some of the under-represented populations include American Indians/Alaska Natives and Asian populations.

**Underused technologies.** The current evidence with respect to barriers and facilitators to the use of patient-centered technologies may be used to guide the development of other technologies, such as personal health records (PHRs) which did not appear in our review. PHRs have been defined as “an Internet-based set of tools that allows people to access and coordinate their lifelong health information and make appropriate parts of it available to those who need it.” PHRs can be tethered (connected) to electronic health records (EHRs) and provide patients with an asynchronous platform to access and update their medical health record data and engage with their health care team [7, 129, 130]. As an example, the unique challenges we identified among Hispanics, including issues related to tailored educational content and content comprehension, may be used to modify patient portals within practices serving a Hispanic community.

**Patient-provider communication and shared decision making.** Our review also highlights the paucity of research regarding how health information technology can improve communication and shared-decision making (SDM) between individuals from vulnerable populations and their health care providers. Whereas increasing provider communication is important in building trust and improving chronic disease management [4], SDM bridges gaps in knowledge, tailors medical and health decisions to patient preferences, as well as increasing patient adherence to treatment and improving health outcomes [131]. More research should focus on the use of these technologies to support providers in providing patients with information on cancer treatment options, as well as describe the advantages and disadvantages of different approaches to technology design and implementation.
Precision medicine. By tailoring content to targeted populations, patient-centered technologies have the potential to facilitate the provision of precision medicine among underserved populations. Precision medicine focuses on the “…prevention and treatment strategies that take individual variability into account” (Collins). Interactive technologies such as social media and mobile devices may take advantage of predictive algorithms to tailor the care of individuals to patients based not only upon their genetic, but their social identities.

Limitations

Our study has several limitations. One potential limitation is that our search strategy may not have captured all potential articles meeting our inclusion criteria. In order to minimize this limitation, we implemented a snowball search method in which we reviewed the references of all included studies for additional citations. Another limitation of our study is that, due to the heterogeneity in study design and types of outcomes evaluated, we were unable to aggregate findings in the manner of a meta-analysis. Lastly, the included articles may be subject to publication bias as studies that report negative findings are less likely to be published.

Conclusions

There is a growing body of literature exploring patient-centered technology and its influence on the care of underserved populations. Despite the potential of patient-centered technologies and their acceptance among disparate populations, challenges still exist with respect to their effective use and usability. With technology changing at an exceedingly rapid pace, more training needs to be provided to in order to ensure these underserved groups are able to
effectively use new and emerging technologies. In addition, tailoring these technologies to unique cultural norms will go far in facilitating their effective use.
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